At the Edge of the Universe:
Latest Results from the Deepest Astronomical Surveys
ASP Conference Series, Vol. 380, 2007
José Afonso, Henry C. Ferguson, Bahram Mobasher, and Ray Norris, eds.

Spitzer Observations of Galaxy Clusters

Dario Fadda
NASA Herschel Science Center - Caltech 100-22, Pasadena CA 91125, USA

A. Biviano
INAF - Osservatorio Astronomico di Trieste, via G. B. Tiepolo 11, 34143 Trieste, Italy

F. Marleau, L. Storrie-Lombardi
Spitzer Science Center, California Institute of Technology, CA 91125, USA

F. Durret
IAP, 98bis Bd Arago, 75014 Paris, France

Abstract. We present preliminary results of a project to study three rich nearby clusters of galaxies with the *Spitzer* space telescope. The *Spitzer* observations in the four IRAC and three MIPS bands cover a region up to three virial radii, approximately, and have been recently completed. On the basis of the first *Spitzer* images, we followed up spectroscopically the far-infrared sources with the multi-fiber spectrograph HYDRA on the WIYN telescope. 70% of the sources brighter than 0.3 mJy at 24 μm and r'$<$ 20.5 have been observed for a total of 1078 spectra. For 87% of them we were able to measure redshifts obtaining 50 to 100 members for the different clusters. This first study shows that the far-IR sources in these clusters are predominantly powered by star formation and clustered in regions far from the center. In the case of A1763, they seem to be situated along a filament supporting the idea of infalling galaxies experiencing bursts of star formation during their first contact with the hot intra-cluster medium.

1. The Project

We have observed with the *Spitzer* Space Telescope (Werner et al. 2004) three clusters of galaxies in the nearby Universe ($z \sim 0.2$) selected among the richest Abell clusters (N$>$80) in the directions of the sky with the lowest Galactic emission in the far-IR ($<$0.4 MJy/sr at 100 μm). This sample of galaxy clusters (including A983, A1731, and A1763) is observed to provide a local reference for observations of distant clusters which are of similar richness because of selection effects. Moreover, the observations cover a wide field to observe galaxies up to three virial radii, approximately (see Fig. 1 and Fig. 2). In fact, under the hypothesis that galaxies falling into the potential well of the cluster from surrounding superstructures experience a burst of star formation at the first contact with the intra-cluster medium, we expect to find more galaxies with obscured star formation in the outskirts of the clusters (see, e.g., Fadda et al. 2000; Geach

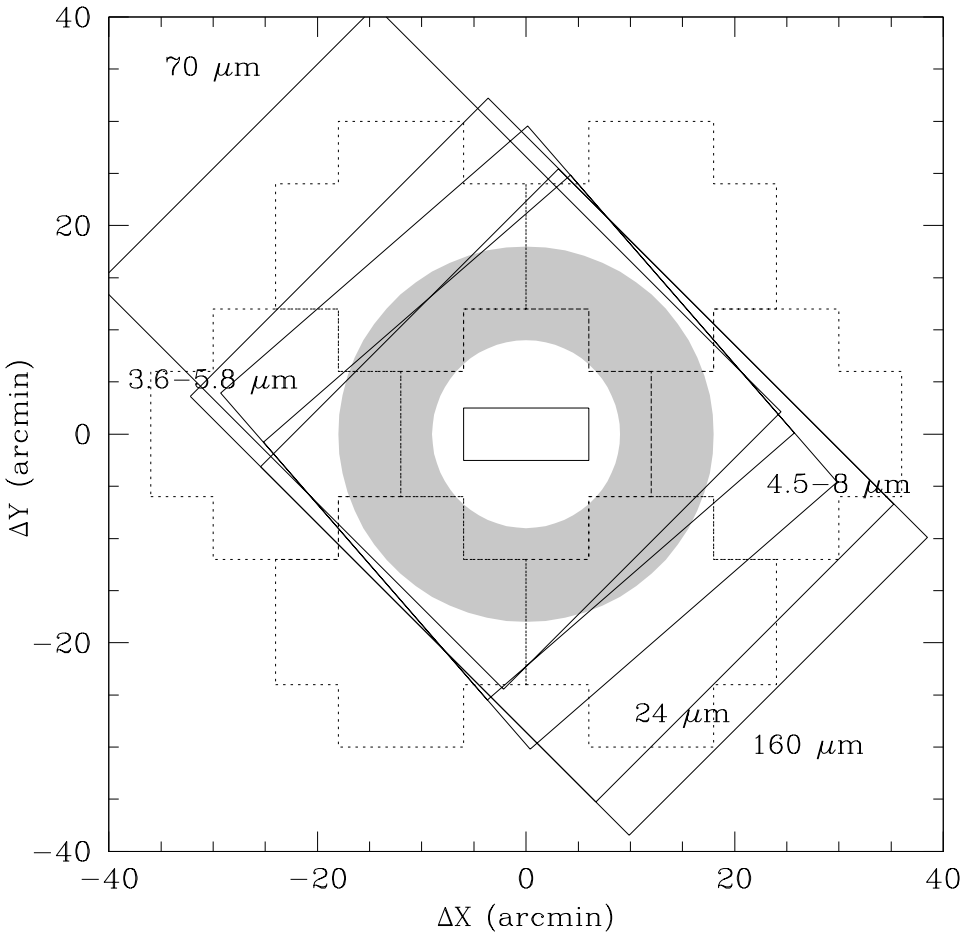

Figure 1. Palomar LFC (crosses) and *Spitzer* (rectangles) observations of the clusters. The grey area marks the region between one and two virial radii at $z \sim 2$.

et al. 2006). Finally, the far-IR observations are deep enough to detect diffuse emission if this is at the levels predicted from the models (see, e.g., Popescu et al. 2000).

2. Data

A total of 30 hours of *Spitzer* time has been assigned to this project and the *Spitzer* observations have been recently completed. The three clusters have SDSS images (in the recent release 5) and two of them have been imaged with the Palomar Large Format Camera (LFC) before the *Spitzer* observations in the r' band (Fig. 1). Spectra for 70% of the sources brighter than 0.3 mJy at 24 μm and with r'$<$ 20.5 have been obtained with the HYDRA multi-fiber

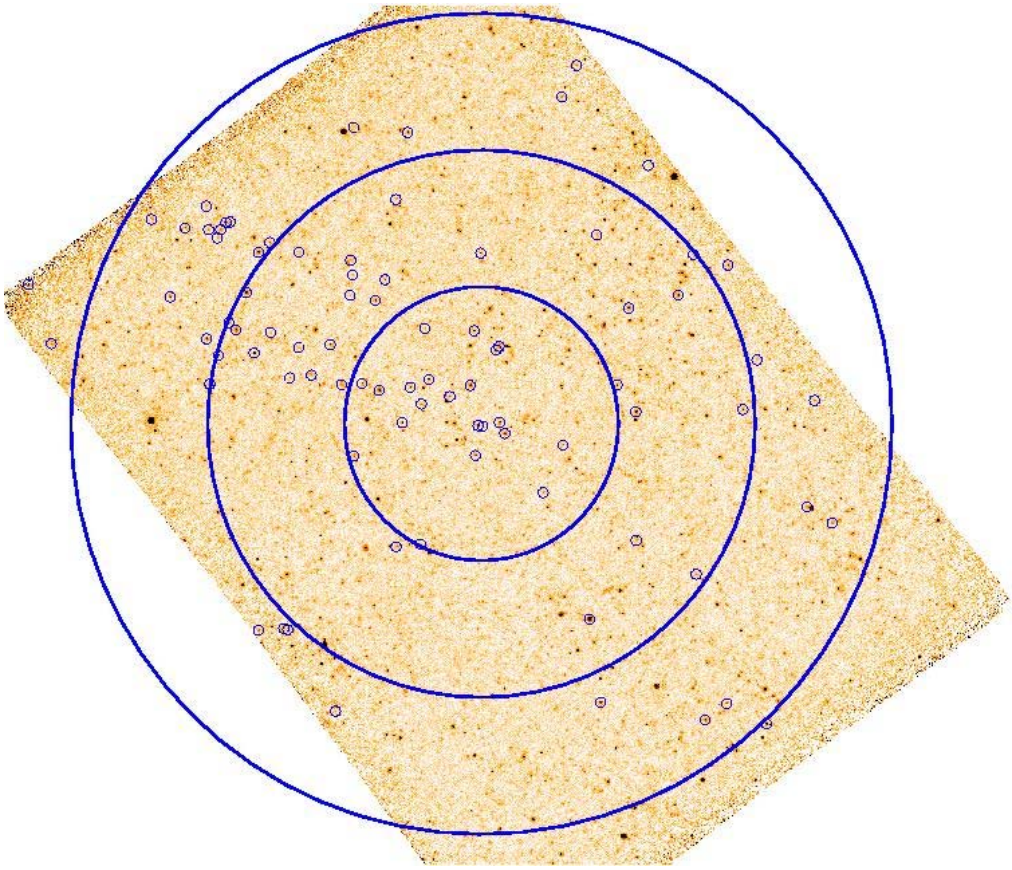

Figure 2. 24μm image of A1763. The three circles mark the distances of one, two and three virial radii. The small circles correspond to 24 μm sources which are spectroscopically confirmed members of the cluster.

spectrograph on the WIYN telescope. Among the 1078 spectra obtained, we were able to measure redshifts for 940 sources, 50 to 100 of which are members of the clusters.

3. Results

The far-infrared sources are neither concentrated in the center nor evenly distributed. In A1763 (Fig. 2), most of the sources are concentrated along a stream in the East direction flowing towards the center of the cluster (the circles mark the three virial radii). Most of the sources are bluer than the color-mag relation of the cluster (Fig. 3). They are therefore actively forming stars. Their spectra show prominent Hα lines and high Hα/Hβ ratios indicating the presence of dust absorption.

Most of the far-IR sources are powered by star formation. In the XMM image of A1763, only one of the far-IR sources of the cluster have clear X-

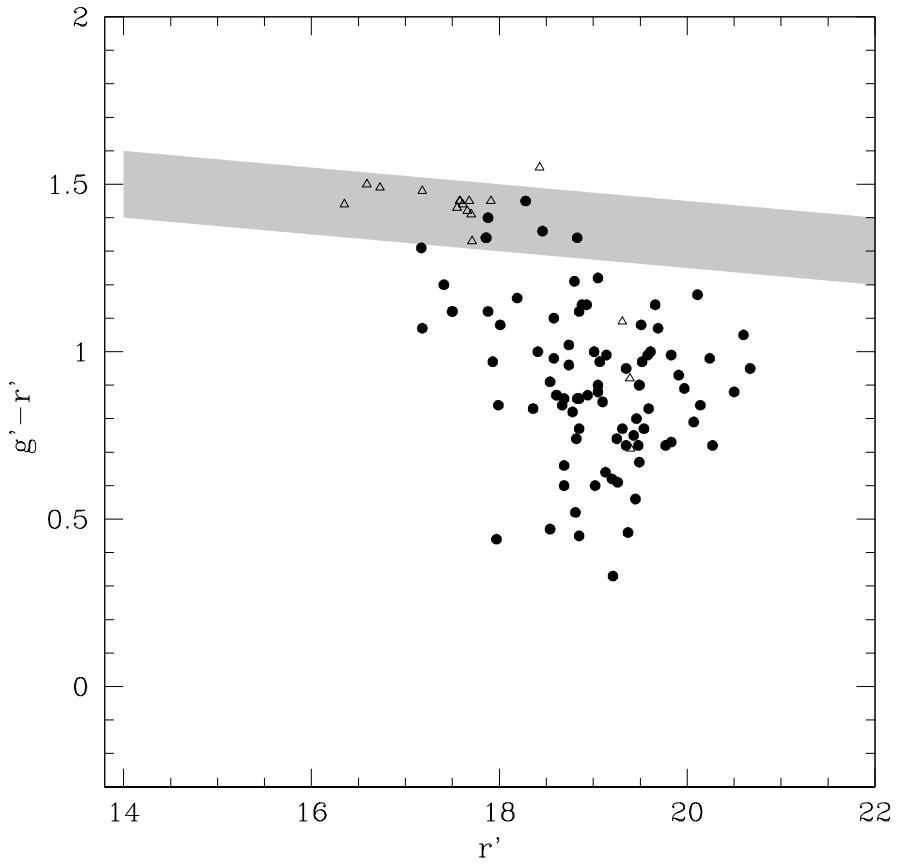

Figure 3. Color-magnitude relation for A1763. Cluster members (circles if emitting at 24 μm, triangles otherwise) are overlapped to the color-mag relation of the cluster (grey band). Most of the sources are blue star-forming galaxies.

ray emission and its nuclear nature is confirmed by the optical spectrum with Hα/[NII] and [OIII]/Hβ ratios typical of AGN.

References

Fadda, D., et al., 2000, A&A, 361, 827
Geach, J. E., et al., 2006, ApJ, 649, 661
Popescu, C., et al., 2000, ApJ, 354, 480
Werner, M. W., et al., 2004, ApJS, 154, 1